qQE
747
C2M56
1911
v.1
VPAL

YALE UNIVERSI
APR 22 1912
LIBRARY

Received from
separate collecti
(Ralph Stewart
220

MEMOIRS
OF THE
UNIVERSITY OF CALIFORNIA

Vol. 1. No. 2

THE FAUNA OF RANCHO LA BREA

PART I. OCCURRENCE

BY
JOHN C. MERRIAM

BERKELEY
THE UNIVERSITY PRESS
1911

MEMOIRS OF THE UNIVERSITY OF CALIFORNIA

Volume 1

1.—Triassic Ichthyosauria, with Special Reference to the American Forms, by John C. Merriam. Pages 1-196, plates 1-18. September, 1908 . Price, $3.00

2.—The Fauna of Rancho La Brea; Part I: Occurrence, by John C. Merriam. Pages 197-213, plates 19-23. November, 1911 30

Volume 2

The Silva of California, by Willis L. Jepson. Pages 1-480, plates 1-85, maps 1-3. December, 1910. Price, in paper covers, $9.00; by express, $9.80. Price, bound in green buckram, $10.00; by express, $10.90.

European orders for the Silva of California should be addressed to
T. Fisher Unwin, Adelphi Terrace, London

QE
747
C2M56
1911
V.1
VPAL

MEMOIRS

OF THE

UNIVERSITY OF CALIFORNIA

Vol. 1. No. 2

THE FAUNA OF RANCHO LA BREA

PART I. OCCURRENCE

BY

JOHN C. MERRIAM

BERKELEY
THE UNIVERSITY PRESS
1911

C. Lewis Gazin
U. S. National Museum
Washington 25, D. C.

INTRODUCTION

Of the numerous occurrences of animal remains representing prehistoric life on the North American continent, the locality at Rancho La Brea furnishes one of the most nearly complete pictures of the fauna of a given region at a given period that has thus far been obtained. When all of the data have been gathered through intensive study of this field, and when the facts thus assembled have been interpreted, we shall have gone far toward reaching an understanding of the biologic and climatic conditions obtaining in the Los Angeles region during one phase of Pleistocene time. So significant do the results of a study of this fauna appear in relation to the general problem of the Pleistocene, that it seems desirable to bring together the conclusions obtained in work on all phases of the assemblage of life forms here represented.

Since receiving the first specimens from Rancho La Brea, in December, 1905, the Department of Palaeontology at the University of California has been almost continuously engaged in a study of this most alluring field. Some of the results obtained have already been presented in brief papers by J. F. Bovard, L. H. Miller, W. P. Taylor, and the writer. Other articles based on material furnished by the University have been written by Wm. J. Sinclair and by Fordyce Grinnell. The present paper is the first of a series of publications in which it is planned to present in full the results of work on all of the groups represented in the Rancho La Brea fauna. It is not to be presumed that all of the facts relating to any of the groups discussed are yet discovered, and the writing of the last word on the Rancho La Brea fauna will probably fall to investigators of a later generation. It is, however, hoped that at this present stage of progress a considerable number of the principal items of information may be brought together; and that from these we may construct at least the foundation for more extensive work such as naturally follows any initial investigation.

In studying the fauna obtained from the Rancho La Brea Beds the writer has been assisted by many persons who have been interested in the work. Particular acknowledgment is due to Madam Hancock Ross and to Mr. Allan Hancock for their courtesy in permitting the University to carry on its excavations in this interesting field. To Mr. F. M. Anderson and Mr. W. W. Orcutt the writer is indebted for the original information which led to so many discoveries. Mr. Anderson presented his first collection to the University, and Mr. Orcutt permitted the use of his material for study.

Excepting a small part of the expense, which has been met from other funds, the financial support of the work has been generously furnished by Miss Annie M. Alexander, whose personal interest in the progress of the investigation has also been an important factor in the advancement of the work.

Dr. William Bebb of Los Angeles most generously presented to the University the first specimen of the gigantic lion found in the asphalt, and has kindly permitted the use of several important specimens of rodents in his collection.

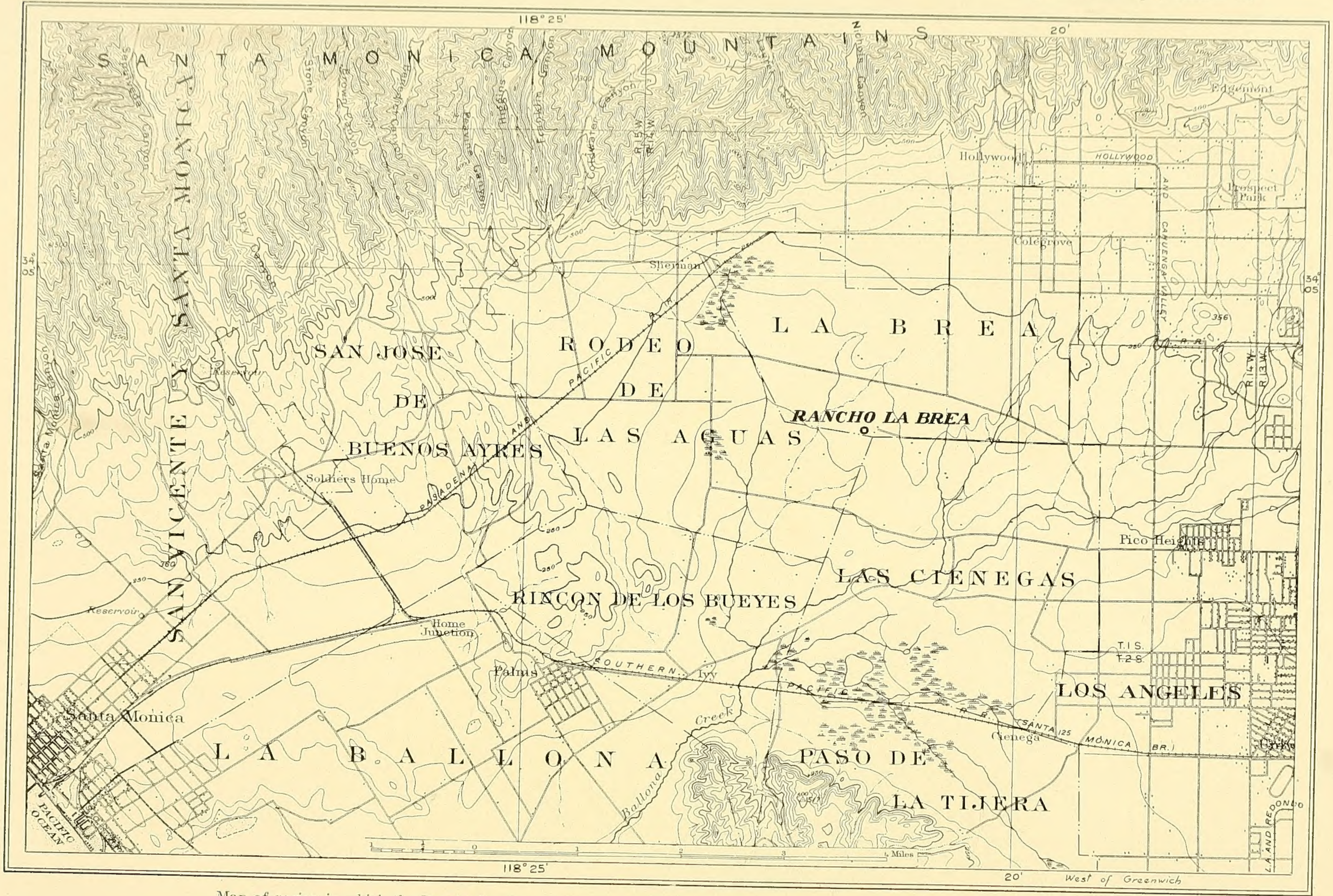
In the course of the work Dr. Ralph Arnold, Mr. W. W. Orcutt, and Mr. A. E. Preston have greatly assisted in the interpretation of the geologic relations of the asphalt beds.

During the last year's work Mr. L. H. Miller assisted in every way possible in the direction of the excavations, and has contributed a considerable number of valuable specimens to the University. Mr. E. L. Furlong brought together some of the most valuable collections in the first two years of work, and also prepared and mounted many of the specimens. Mr. E. J. Fischer efficiently carried on the work of collection for approximately a year, and has presented several specimens obtained by him before his connection with the University. Dr. C. O. Esterly of Occidental College and Dr. F. C. Clark of the Pacific College of Osteopathy have both assisted very generously through loan and gift to the University of valuable specimens needed for study.

In bringing together such information relating to the Los Angeles asphalt beds as could be obtained from the notes of early explorers, the writer has been much indebted to Professor Frederick J. Teggart and Mr. Porter Garnett for information indicating that the Rancho La Brea locality may have been visited by Gaspar de Portolá.

In connection with the study of special divisions of the fauna considered in later parts of this series of publications, the writer has been grateful for many courtesies extended. Acknowledgment of such services properly appears with a discussion of the materials especially concerned, and is reserved for mention in other parts of the series.

UNIVERSITY OF CALIFORNIA,
May 16, 1911.



Map of region in which the Rancho La Brea Beds are situated. Adapted from U. S. Geological Survey topographic map.

HISTORICAL

The extensive asphalt beds occurring at Rancho La Brea, on the western border of the city of Los Angeles, have been known for many years as one of the most interesting of the numerous bitumen deposits of the state, and have attracted the attention of many investigators concerned with the geology of this region.

The earliest description of bituminous deposits in the Los Angeles region known to the writer is found in the narrative of the Portolá Expedition,[1] written in 1769. In the account of the region traversed, mention is made of springs of pitch, which were observed at a stage in the journey when the party must have been in the vicinity of Rancho La Brea. While it is not possible to make certain of the exact location of the pitch springs described, a study of the route followed gives good reason for suspecting that the locality was actually Rancho La Brea.

Tar pools in the vicinity of Los Angeles were mentioned by Blake[2] in his geological report included in the Pacific Railroad Survey, though it is not clear that he referred particularly to those at Rancho La Brea. Blake's statement is as follows:

> There are several places in the vicinity of the city (Los Angeles) where bituminous or mineral pitch rises from the ground in large quantities. These places are known as tar springs, or pitch springs, and some of them form large ponds or lakes. One of the springs was passed on our way to the city, and was near the outcrop of bituminous shale in the banks of the creek already described. This spring was nothing more than an overflow of the bitumen from a small aperture in the ground, around which it has spread on all sides, so that it covers a circular space about 30 feet in diameter. The accumulated bitumen had hardened by exposure and its outer portions were mingled with sand, so that it was not easy to determine its precise limits. It formed a smooth, hard surface like a pavement, but toward the center it was quite soft and semifluid, like melted pitch. The central portion of the overflow was higher than its margin; and it was evident that all the hard portion had risen in a fluid state and by the heat of the sun had been gradually spread out over the surface; at the same time being constantly exposed to dust, it had become so thoroughly incorporated with it that the compound had all the consistency of an artificial mixture.

---

[1] Diary of Gaspar de Portolá during the California Expedition of 1769–70. Edited by Donald Eugene Smith and Frederick J. Teggart. Publ. Acad. Pacif. Coast Hist., vol. 1, p. 53, October, 1909.—"The 3rd (August 3, 1769), we proceeded for three hours on a good road; to the right of it were extensive swamps of bitumen which is called *chapapote*. We debated whether this substance, which flows melted from underneath the earth, could occasion so many earthquakes." Also mentioned in Diary of Miguel Costansó, Portolá Expedition of 1769–70. Edited by Frederick J. Teggart. Publ. Acad. Pacif. Coast Hist., vol. 2, p. 183, August, 1911.

[2] Blake, W. P., Pacific Railway Reports, vol. 5, Geological Report, p. 76, 1857.

In 1865 J. D. Whitney, then state geologist, in writing his report on the general geology of the Los Angeles region, gave a brief discussion[3] of the asphalt exposures and tar pools. He referred in his report to the "very large amount of the hardened asphaltum mixed with sand and the bones of cattle and birds which have become entangled in it," but did not state that the remains were those of extinct forms. Whitney's discussion of these beds appears in the succeeding paragraph:

> About seven miles due west of Los Angeles is the most important of the numerous tar-springs seen in this vicinity. It is from here that most of the asphaltum used in the town is obtained. Over a space of fifteen or twenty acres, the bituminous material (which when seen by us, in the winter, had exactly the consistency and color of tar) was oozing out of the ground at numerous points. It hardens on exposure to the air, and becomes mixed with sand and dust blown into it, and is then known as "brea." The holes through which the bitumen comes to the surface are not large, few being more than three or four inches in diameter. On removing the tarry substance from the holes, by repeatedly inserting a stick, the empty cavity was very slowly filled up again. At one place there was a pit several yards square, and six or eight feet deep, from which the tar had been taken; but it was filled with water, at the time of our visit, in consequence of late heavy rains. . . . A very large amount of the hardened asphaltum, mixed with sand and the bones of cattle and birds which have become entangled in it, lies scattered over the plain.

As nearly as can be determined, the first published statement in which reference was made to the fossil remains entombed in the asphalt at Rancho La Brea is the following issued by William Denton[4] in 1875:

> The locality is known as Major Hancock's Brea Ranch, and is about eight miles west of Los Angeles, in the valley of the Santa Anna. The bed of asphaltum here covers sixty to eighty acres, and at a depth of thirty feet no bottom has been reached. Thousands of tons have been removed for roofing, paving and combustion, but the supply is almost inexhaustable.
>
> Major Hancock had about twenty-five Chinamen employed in digging out the best of the asphaltum, which is soft enough to agglutinate in the heat of the sun. The material was conveyed to large, open iron boilers, in which it was boiled for twenty-four hours, and then run into sand molds; subsequently it was broken up, for it is quite brittle after being thus boiled, carted for nine miles and shipped to San Francisco, where it was sold for twenty dollars a ton for making asphalt pavement. The bed is about three miles south of the Santa Monica range of mountains, and it appears to lie parallel with them.
>
> Beds of petroleum shale of tertiary age, having in many places a thickness of about two thousand feet, are to be found along the California coast, and at some distance in the interior; they are said, by Professor Whitney, to extend from Cape Mendocino to Los Angeles, a distance of about four hundred and fifty miles. They are exposed in cliffs on the coast near Santa Barbara and Carpinteria, and other places. This shale, there is good reason to believe, is the deposit from which all the asphaltum of California has been derived.
>
> Although this shale is not exposed in the vicinity of the Brea Ranch, it is exposed in various localities at but a short distance, and doubtless underlies the asphaltum deposit, for hundreds of "tar-springs" exist in the vicinity, from which the material is still flowing over the surrounding

---

[3] Whitney, J. D., Geol. Surv. Calif., Geology, vol. 1, pp. 174 and 175, 1865.

[4] Denton, Wm., Proc. Boston Soc. Nat. Hist., vol. 18, p. 185, 1875.

> locality, the springs being in some cases elevated, by its deposition around them, several feet above the surrounding level.
>
> Major Hancock presented me with what I found to be a canine tooth of a Machairodus, a great saber-toothed feline. It was found at the depth of fifteen feet in the asphaltum. The tooth is nine and a half inches in length, measured along the curve, and the breadth of the crown at the base is an inch and three-quarters, being larger than any tooth of the European Machairodus, whose measurement I have been able to find. The crown of the tooth is broken, and its entire length could not have been less, I think, than eleven inches. The tooth from the Val d'Arno, in Italy, referred to by Falconer in his Palaeontological memoirs, measures eight and one-half inches in length, and the breadth of the crown at the base is one and one-half inches, while the tooth found by McEnery in Kent's Hole, England, is six inches in length, and one and one-fifth inches in breadth. The California tooth is closely serrulated on both the concave and convex sides. It seems to have been exposed to the action of the elements for a long time, and contains a number of fractures, some of which have been united by the asphaltum in which it was imbedded.
>
> I obtained a number of teeth of the fossil horse, and bones of the deer, a large bovine animal, the otter, seal, albatross, and other animals. I found near the pit a portion of the right upper jaw of the fossil horse, containing four molar teeth, or three premolars and one true molar. The first premolar is smaller in proportion to the size of the other teeth than those of the recent horse, judging by several with which I have compared it, and smaller than those of the fossil horse of India. It is but one inch in length, and three-quarters of an inch in breadth; but the other three teeth are larger than the average of the recent horse. The Machairodus tooth, with several from the fossil horse, were exhibited.

Denton considered the asphalt to be derived from petroleum shales of Tertiary age which were known to be exposed at localities near by, and were presumed to lie beneath the asphalt deposits. Evidence of this was found in the presence in this region of hundreds of tar springs from which the tar was still flowing over the surrounding areas, the springs being in some cases elevated to a height of several feet above the normal level of the ground by deposition of bituminous material.

The first fossil specimen from the asphalt mentioned by Denton is a canine tooth of a large saber-tooth cat, the tooth having been presented to him by Major Hancock. The presumption is therefore that Major Hancock was the first person to take particular notice of the fossil remains in the asphalt.

The saber-tooth canine was stated to have been found at a depth of fifteen feet in the asphaltum, so that no question could arise as to its belonging in the asphalt formation. This tooth was compared with *Machairodus* of Europe, but seemed to represent a larger animal.

Denton also obtained bones and teeth of a fossil horse, and bones considered to represent the deer, a large bovine animal, the otter, seal, albatross, and other animals.

As nearly as can be determined, no other investigator seems to have followed up the work of Denton, which was quite forgotten; and for many years past the great quantities of bones scattered about the refuse heaps, and exposed in the old quarries, have been considered as representing nothing more than remains of domestic and other animals of this region, which had been trapped in the tar in comparatively recent time.

During the past twenty years the writer has heard frequent mention of bones present in the asphalt deposits, but has always been assured that the remains were unquestionably those of Recent animals, mainly cattle and horses which had been mired in the tar.

So far as the writer has been able to learn, since the discovery by Denton Mr. W. W. Orcutt of Los Angeles was the first person to recognize the remains at Rancho La Brea as evidently fossils, or as belonging to a geological period preceding the present. In December, 1905, Mr. F. M. Anderson visited the Rancho La Brea beds with Mr. Orcutt, and procured a number of fragmentary specimens, including a portion of a saber-tooth skull, several teeth of the great wolf, and a number of dermal ossicles of a ground-sloth. These specimens Mr. Anderson very kindly placed at the writer's disposal. Realizing the importance of the discovery, the locality was visited by the writer, in company with Dr. Ralph Arnold and Mr. A. E. Preston, soon after seeing Mr. Anderson's material. With the assistance of Dr. Arnold and Mr. Preston a small collection of typical specimens was brought together. It was upon this material, together with that presented by Mr. Anderson, that the first descriptions of remains obtained from these deposits were based by the writer.[5]

Some months after the first visit, the field was examined again by the writer under the guidance of Mr. Orcutt, who furnished much valuable information concerning the geologic relations of the region. Regular collecting was begun soon after this, and has been carried on by the University of California since 1906. The total amount of field work aggregates about fifteen months of continuous excavation.

Immediately after the first specimens from Rancho La Brea had been examined by the writer, application was made to the owner of the property for permission to carry on excavations for scientific purposes, and Madam Hancock Ross very graciously allowed the University to take up the work at that time.

---

[5] Merriam, J. C., Science, n. s., vol. 24, p. 248, 1906. See also Bovard, J. F., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 157, 1907.

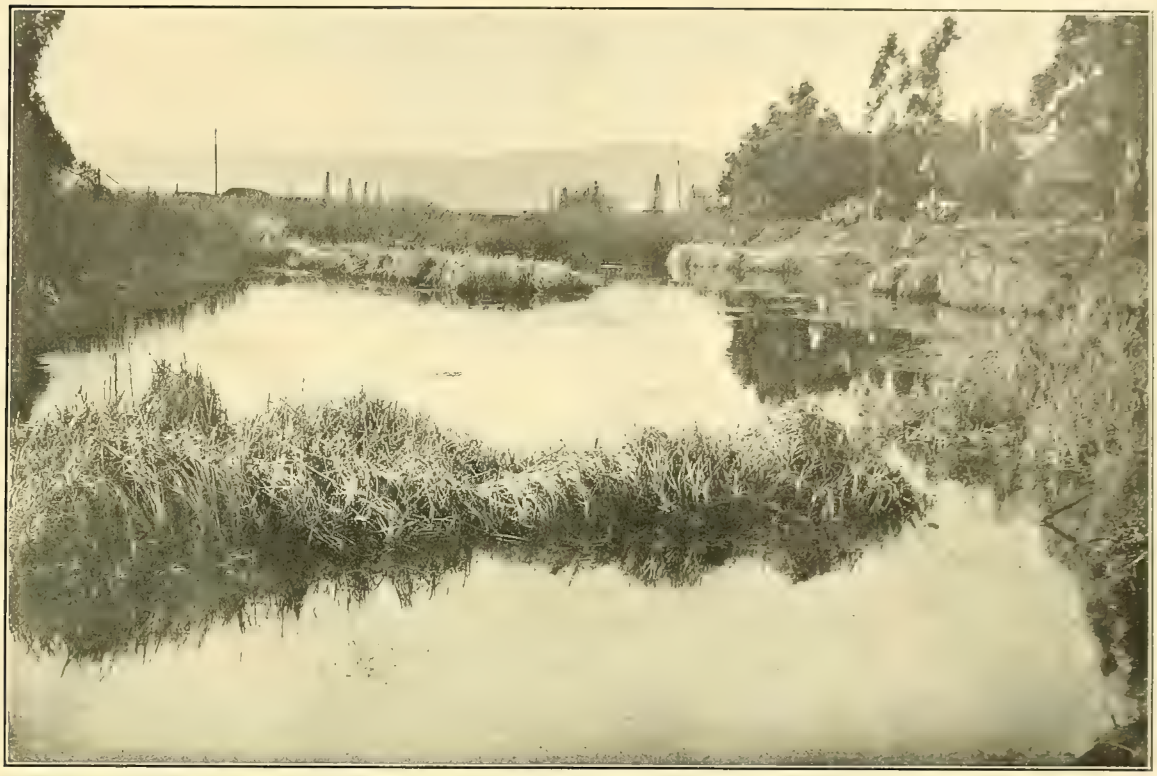


Fig. 1. The lagoon at Rancho La Brea. The surface of the pond is streaked with oil, and gas bubbles are seen escaping through the water. The banks around the lagoon consist to a large extent of asphalt.

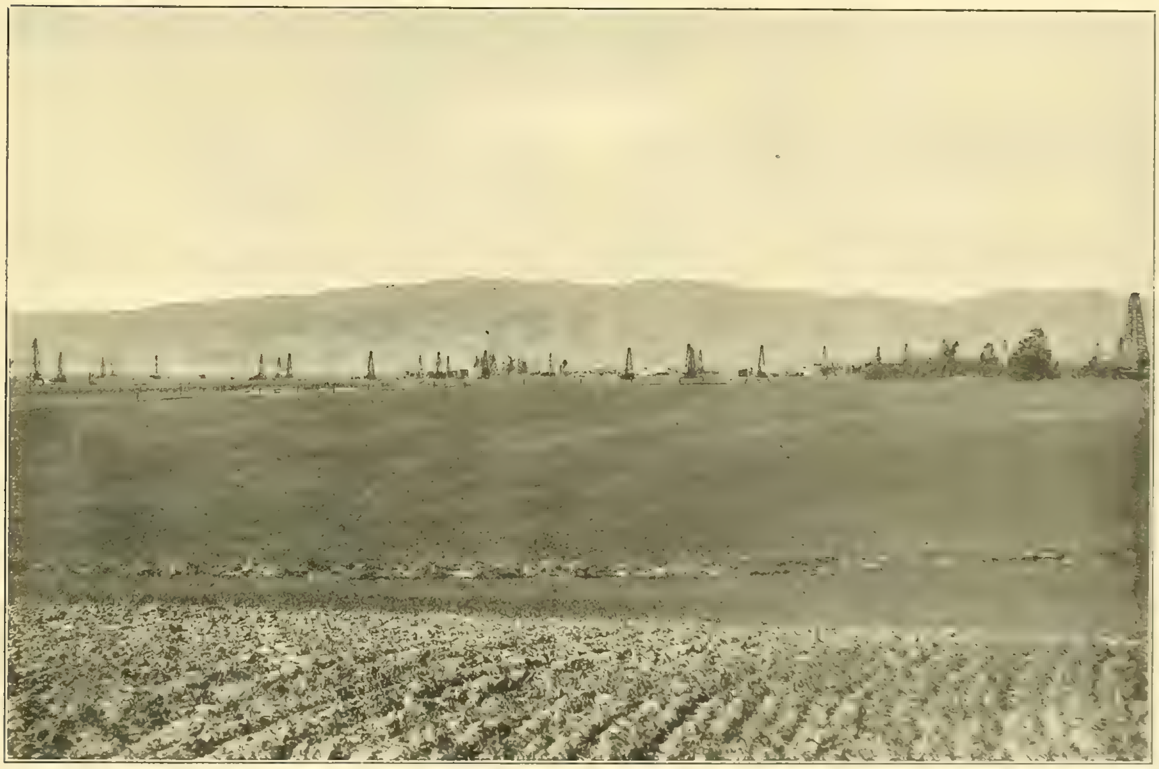


Fig. 2. General view looking north toward the Santa Monica Range, and across the region in which the type locality of the Rancho La Brea Beds is situated. The lagoon is situated in the middle ground to the right.

DESCRIPTION OF THE TYPE LOCALITY

The fossiliferous asphalt deposits for which the name Rancho La Brea Beds has been used were so designated from their occurrence at Rancho La Brea, on the western side of the city of Los Angeles. The exact situation of the typical locality is as follows: SW 1/4, sec. 21, T. 1 S, R. 14 W, San Bernardino Base and Meridian. At this place excellent exposures are seen within a radius of a few hundred yards of a small lake near the old Hancock ranch house. The best exposures are found in the banks bordering several extensive open cuts made by Major Hancock many years ago in excavating asphalt for commercial purposes. The lake or lagoon and several small ponds in the vicinity occupy depressions formed in mining asphalt. The work done by Major Hancock in exposing extensive areas of the brea beds, and thus making them easily accessible for examination by geologists and palaeontologists, has been in a large measure contributory to the advancement of our knowledge of this region, as otherwise the fossil-bearing beds might easily have escaped notice.

The Rancho La Brea Beds lie in a wide stretch of slightly rolling country immediately to the south of the abrupt southern slope of the Santa Monica Range. The typical exposures are situated about two and one-half miles from the southern base of the range, and are about two hundred feet below the level from which the mountains rise abruptly.

In the region immediately about the type locality asphalt is exposed in many places, and is evidently only a short distance below the surface over an area at least as large as that in which it actually outcrops. At many points in this region tar springs or seeps pour out considerable quantities of bituminous material. The flow from these seeps is fairly regular in some cases, but at other points more or less irregular exudation occurs through small crater-like vents. The phenomena of extravasation of bituminous products are seen to best advantage in the immediate vicinity of the lagoon or lake, where tar springs and tar seeps are readily discovered. In addition to the outflow of the heavier substances, large quantities of gas may be observed coming up through the water of the lake in great bubbles.

Estimates of the probable extent of the territory in which asphalt beds lie at or near the surface have been made by several persons familiar with this region. The approximations range from about a square mile down to one-fourth of a square mile. The probabilities seem in favor of making the estimate too low rather than too high.

NATURE AND ORIGIN OF THE RANCHO LA BREA BEDS

The formation in which the fossil bones occur at Rancho La Brea is essentially an alluvial accumulation consisting mainly of beds of clay, sand, and asphalt. In some places bedding planes are quite distinctly shown, especially in the clay or sand strata. At other localities the deposit has been irregular or in pockets, and minor local movements of the asphalt or clay masses have possibly increased the irregularity of the beds. The asphalt may occur as a nearly pure bituminous deposit, though it is usually mixed with sand, clay, or other materials. In some places it appears as fairly definite strata, while at other points it has irregularly impregnated beds of sandy or clayey material, and no definite bedding is shown.

The thickness of the asphalt deposits containing bones has not been determined, but these beds probably extend considerably deeper than the lowest levels yet reached. A depth of at least thirty feet is recorded for the work carried on by Major Hancock, and nearly the same horizon has been attained in recent excavations.

The formation in which the asphalt appears has been penetrated by the wells in the Salt Lake Oil Field immediately to the north of the principal brea outcroppings, and seems also to be a part of a series of beds comprising a considerable thickness of sand and clay strata exposed in the hills immediately to the south. The well records of the Salt Lake Field, as described by Arnold,[6] indicate the presence of Pleistocene strata from fifty to one hundred feet in thickness overlying the Tertiary formations in which the main oil-bearing beds are found. The Pleistocene section penetrated by the oil wells comprises alluvium, clay, coarse sand, gravel, and asphalt, the deposits being apparently all of fresh-water or alluvial origin. Asphalt is well represented down to the bottom of the Pleistocene portion of the section.

The formation exposed in the low, flat ridges immediately to the south of Rancho La Brea is apparently a part of the series represented by the fossil-bearing strata at Rancho La Brea and by the Pleistocene penetrated in the oil wells of the Salt Lake Field. The ridges south of the fossil beds are considerably eroded and terraced, and it is to be presumed that the erosion which is indicated occurred in Pleistocene time. It is therefore probable that the fossiliferous beds now exposed at Rancho La Brea were at one time covered by many feet of strata, which have been removed by erosion inaugurated before the beginning of the Recent epoch.

---

[6] Arnold, R., U. S. G. S. Bull. no. 309, p. 187, 1907.

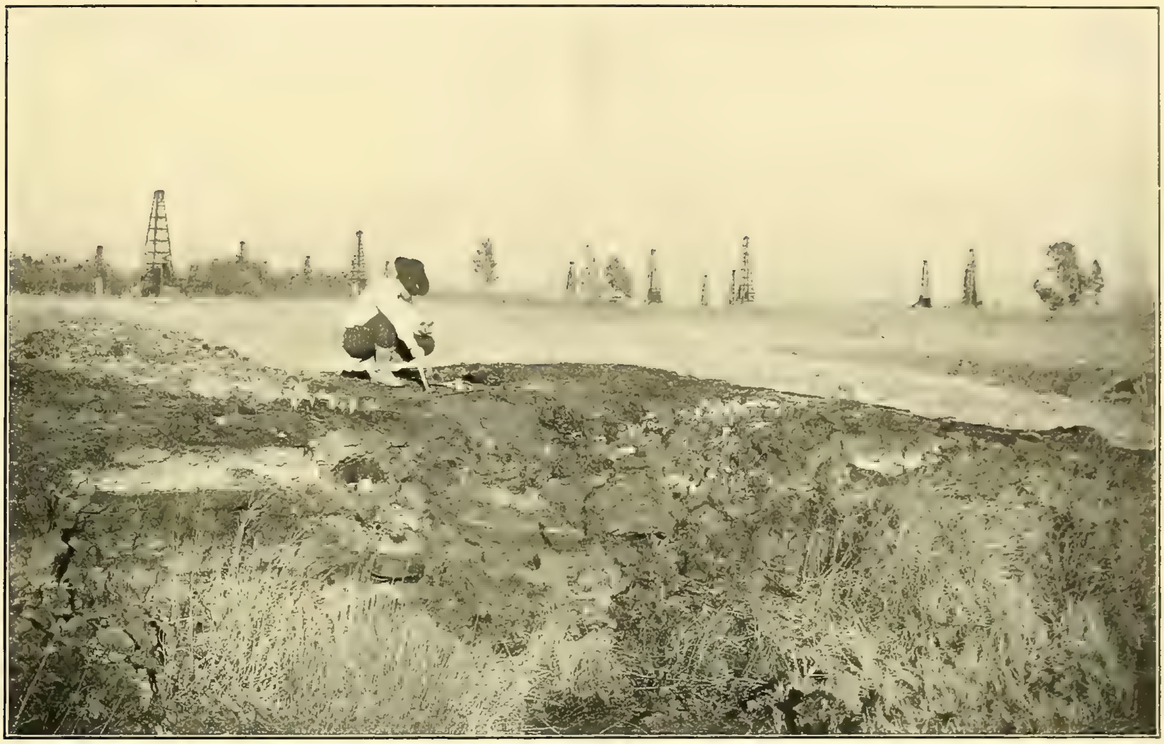


Fig. 1. The locality at which the principal excavation work of the University of California has been carried on. The exposure to the left shows separation of distinct strata. The small white patches in the asphalt represent weathered bones still in the original matrix. Photograph by Ralph Arnold.

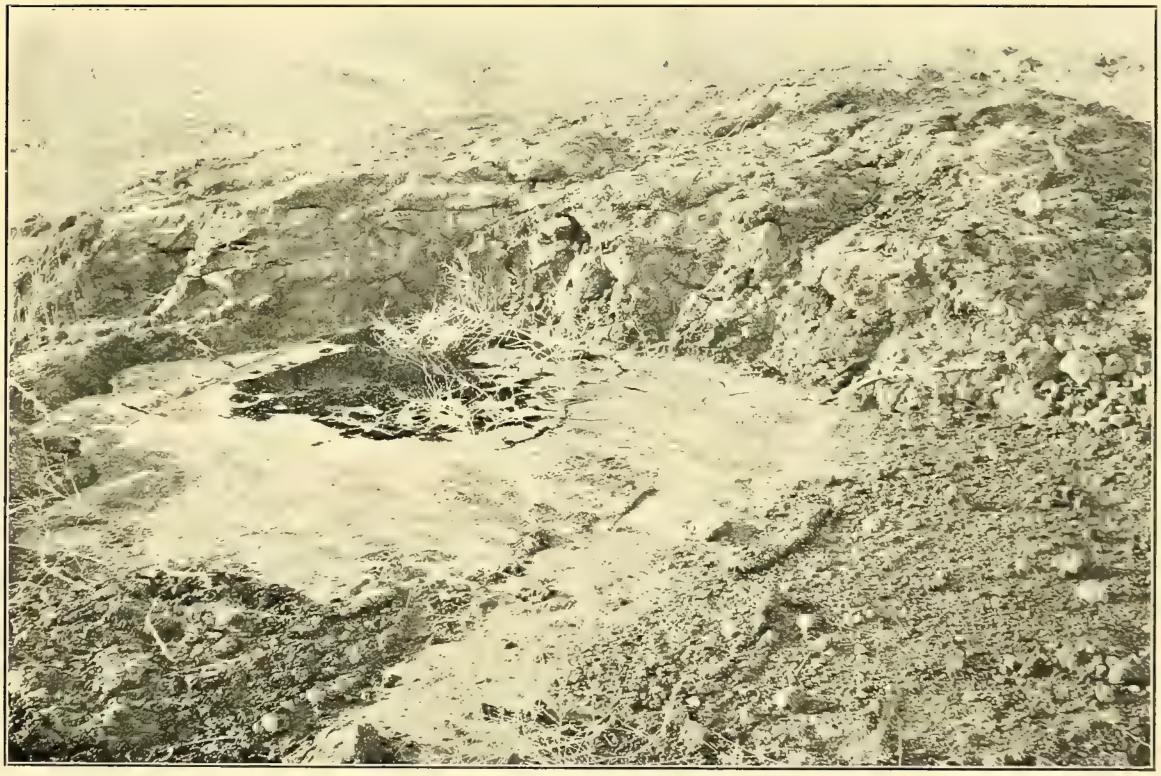


Fig. 2. A tar seep. The area in the middle of the seep is very soft. Toward the margins the surface gradually hardens.

Geologists who have made a study of this region are generally in agreement that the asphalt of Rancho La Brea originates in the shale formations which underlie the Pleistocene beds. According to Arnold, Orcutt, and others who have made a special examination of the conditions in the area west of Los Angeles, the Fernando formation, which immediately underlies the Pleistocene beds of the Salt Lake Oil Field, is in this region compressed into a fold, and there are reasons for considering that the crest of this fold is more or less irregularly broken, thus offering an unusual opportunity for the escape of bituminous substances at this place. The seepage of oil and tar has presumably been in progress almost continuously during the whole period of formation of the Rancho La Brea Beds. The asphaltum deposit which has formed represents the residuum left after evaporation of the more volatile portions of the oil. In accordance with slightly varying conditions of deposition, the supply of asphalt has at times been relatively abundant enough to form the greater part of the accumulation; at other times it has sufficed only to make up a small fraction of the material being heaped up in this place.

In the earlier stages of deposition of the Pleistocene formation the quantity of oil reaching the surface would presumably be larger than in the later periods, when the thick accumulation of beds, consisting in part of asphalt, would tend to prevent the escape of bituminous substances coming up from the lower formation. During the later stages of accumulation, as at the present time, it is evident that in addition to slow seepage through the mass, a part of the oil and gas reached the surface through fairly defined channels or pipes. Through passageways of this nature, which are common at Rancho La Brea, the movement of masses of tar may take place spasmodically, the holes being apparently empty at times, and on other occasions discharging voluminously.

The mode of accumulation of the deposit is pretty clearly illustrated by the conditions now obtaining in the vicinity of Rancho La Brea. This region is at the present time a comparatively level country bordered on the northern side by the Santa Monica Range, which rises abruptly to an elevation of about twelve hundred feet above the plain. The lowlands are traversed by a few drainage lines along which detritus is carried from the Santa Monica Range, or from the lower hills, to the east and south. At a number of localities the drainage is so balanced that water easily accumulates to form marshy spots. Tar seepages are common, and lenses of asphalt of irregular shape and thickness are continuously forming.

The relation of the formation containing the mammalian fauna at Rancho La Brea to the marine Pleistocene beds of the San Pedro Series[7] occurring only a few miles to the south is not as yet entirely clear. From Arnold's investigations it would appear that the alluvial or fresh-water Pleistocene of the

---

[7] Arnold, R., Mem. Calif. Acad. Sci., vol. 2, 1903.

Salt Lake Oil Field is nearly continuous with marine beds of upper San Pedro age. As the Rancho La Brea Beds are, so far as known, an alluvial accumulation, they are presumably not perfectly continuous with the marine San Pedro, though an oscillating shore line might cause the interdigitation of marine and alluvial lenses, or estuary conditions might give a gradation from fresh-water to marine beds. That the shore line changed its position somewhat during the deposition of the San Pedro Series is evidenced by the unconformity between the upper and lower members of this series, and by the varying nature of the deposits of the Upper San Pedro. The unconformity between the upper and lower divisions indicates considerable crustal movements.

A suggestion as to the relative age of the Rancho La Brea and San Pedro beds is perhaps to be obtained by consideration of possible relationship of the crustal movements which have affected the two groups of deposits. The series of strata at Rancho La Brea and in the Salt Lake Oil Field is presumably derived in a large measure from erosion of the Santa Monica Range immediately to the north. The abrupt southern slope of this range can hardly be explained on any hypothesis other than that it represents a fault-scarp. In the Salt Lake Oil Field the Pleistocene alluvial beds consist in general of coarser materials below and finer above, showing a gradual adjustment of accumulation to conditions somewhat similar to those obtaining at the present time. Excepting the Recent alluvium, no series of beds later than those in the Pleistocene section penetrated by the oil wells has been observed in the immediate vicinity, and it is to be presumed that these Pleistocene beds represent the accumulation following the last important movement along the fault bordering the southern side of the Santa Monica Range. In view of the fact that the topography of this range is considered to indicate the completion of the faulting movement at no very remote date, it is not improbable that one of the last movements occurred in the period of local changes which were taking place during the deposition of the San Pedro, or at the close of that time. It is true that important movements have occurred in this region of the coast since the deposition of the San Pedro Series, as is evidenced by the prominent coastal terraces which have cut sharply into the San Pedro. Terraces of importance crossing a formation apparently not to be distinguished from the Rancho La Brea Beds have also been referred to as occurring in low hills south of the Salt Lake Oil Field. These movements have, however, been largely of an epeirogenic character. They do not appear to have been accompanied by local faulting, and may not have changed the tectonic relations of the formations at San Pedro and in the vicinity of the Santa Monica Range.

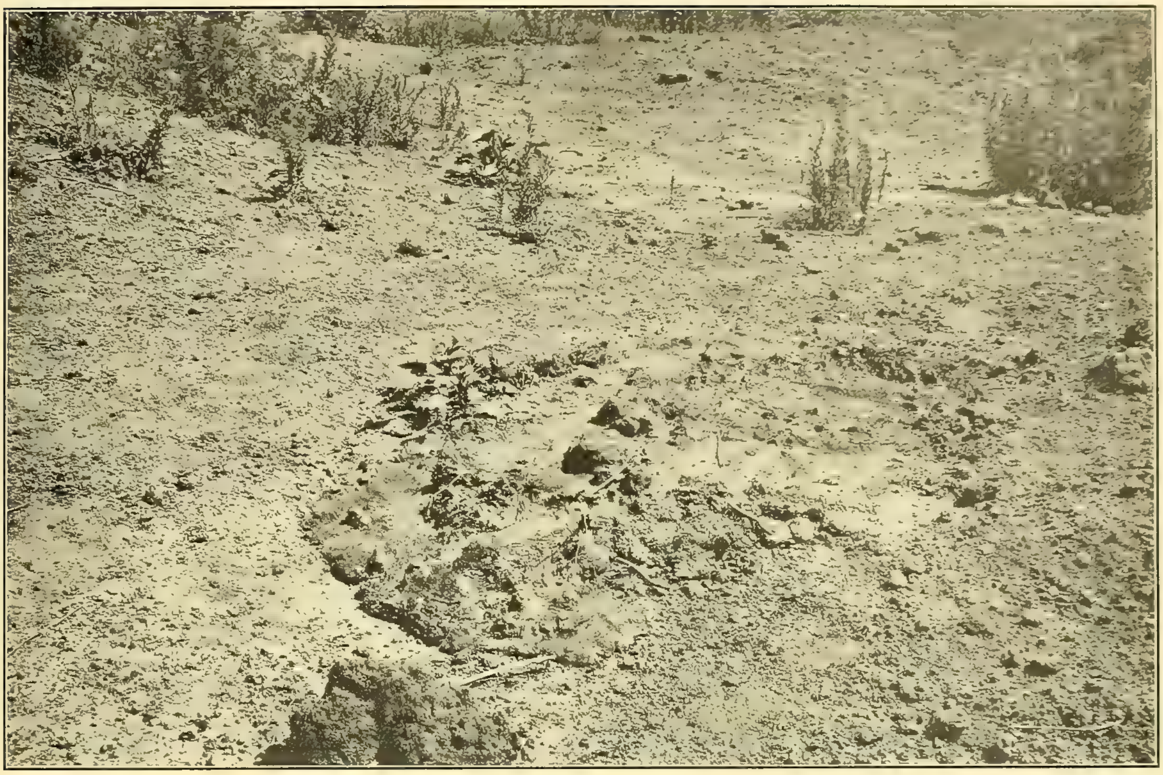


Fig. 1. A pool of asphalt which has come to the surface through a small pipe or channel. The tar has mixed with the soil, so that its boundaries are not readily seen.

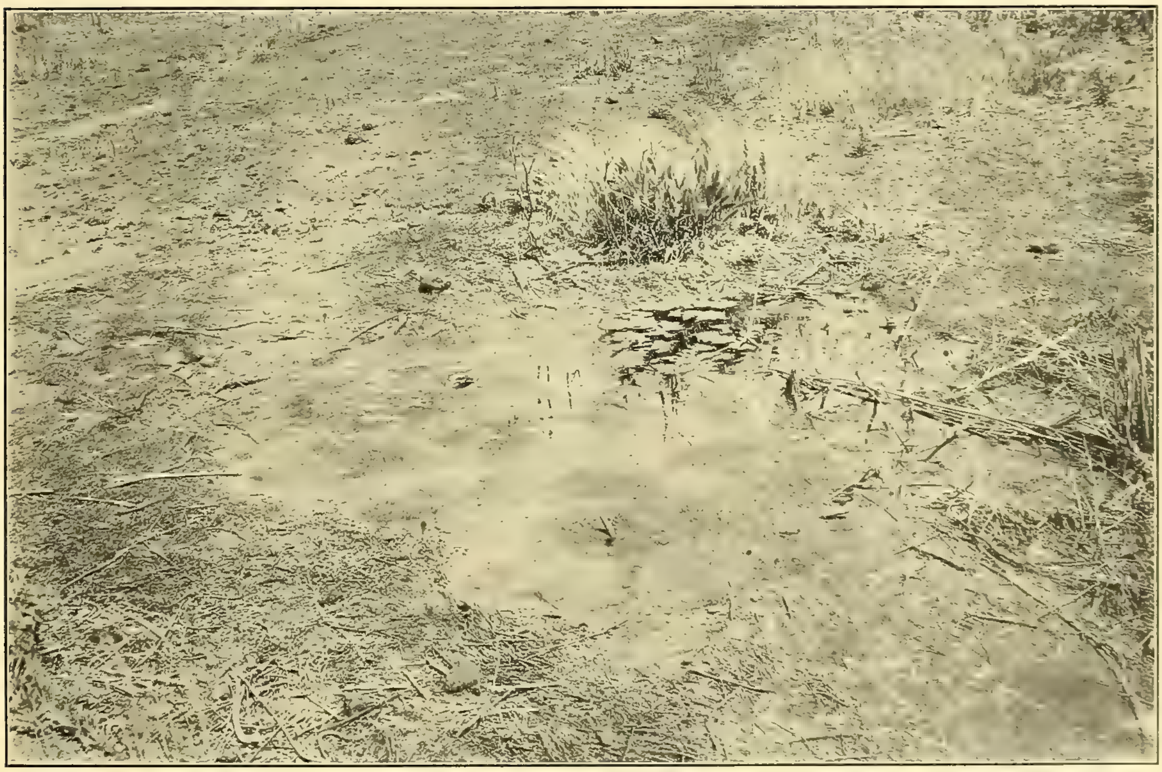


Fig. 2. A tar seep coming up through the soil where the ground has been largely occupied by grass and weeds. Puddles and ponds of tar thus formed trap many small animals.

MODE OF ACCUMULATION OF THE FOSSIL REMAINS

The accumulation of the remains embedded in the fossil beds at Rancho La Brea, as also their assembling in the greater number of the asphalt deposits of southern California, has evidently been controlled by conditions differing largely from those which have produced other kinds of fossil deposits. In the excavation work which has been carried on at Rancho La Brea up to the present time, though a considerable variety of deposits has been encountered, the fossil bones are found to be almost entirely confined to beds which are either pure asphalt or consist of some other material impregnated with tar. When pure sand or clay is present without a tar impregnation there is a conspicuous absence of skeletal remains. While it is possible that some of the impregnated strata may have received their bituminous content since the bones were deposited, the facts of occurrence seem to indicate quite clearly that the presence of tar is the condition which has controlled the accumulation of skeletal remains.

The manner in which tar or asphalt pools may catch unsuspecting animals of all kinds is abundantly illustrated at the present time in many places in California, but nowhere more strikingly than at Rancho La Brea itself, where animals of many kinds have been frequently so firmly entrapped that they died before being discovered, or if found alive were extricated only with the greatest difficulty. As seen at this locality, the tar issuing from springs or from seepages is an exceedingly sticky, tenacious substance which is removed only with the greatest difficulty from the body of any animal with which it may come in contact. Small mammals, birds, or insects running into the soft tar are very quickly rendered helpless by the gummy mass, which binds their feet, and in their struggles soon reaches every part of the body. Around the borders of the pools the tar slowly hardens by evaporation of the lighter constituents until it becomes as solid as an asphalt pavement. Between the hard and the soft portions of the mass there is a very indefinite boundary, the location of which can often be determined only by experiment, and large mammals in many cases run into very tenacious material in this intermediate zone, from which they are unable to extricate themselves.

Judging from reports of the earliest observers who examined the tar seeps at Rancho La Brea, some of the pools were many feet in diameter in their natural state, and might easily in the course of years have caught a great number of even the largest mammals.

In the natural accumulation of remains at the tar pools through accidental entangling of animals of all kinds, it is to be presumed that a relatively large percentage of the individuals entombed would consist of young animals with insufficient experience to keep them away from the most dangerous places, or with insufficient strength to extricate themselves. There would also be a relatively large percentage of old, diseased, or maimed individuals that lacked strength to escape when once entangled. In the census of remains that have been obtained up to the present time the percentages of quite young, diseased, maimed, and very old individuals are certainly exceptionally large compared with what has been seen by the writer in average collections of remains of similar animals accumulated under other conditions.

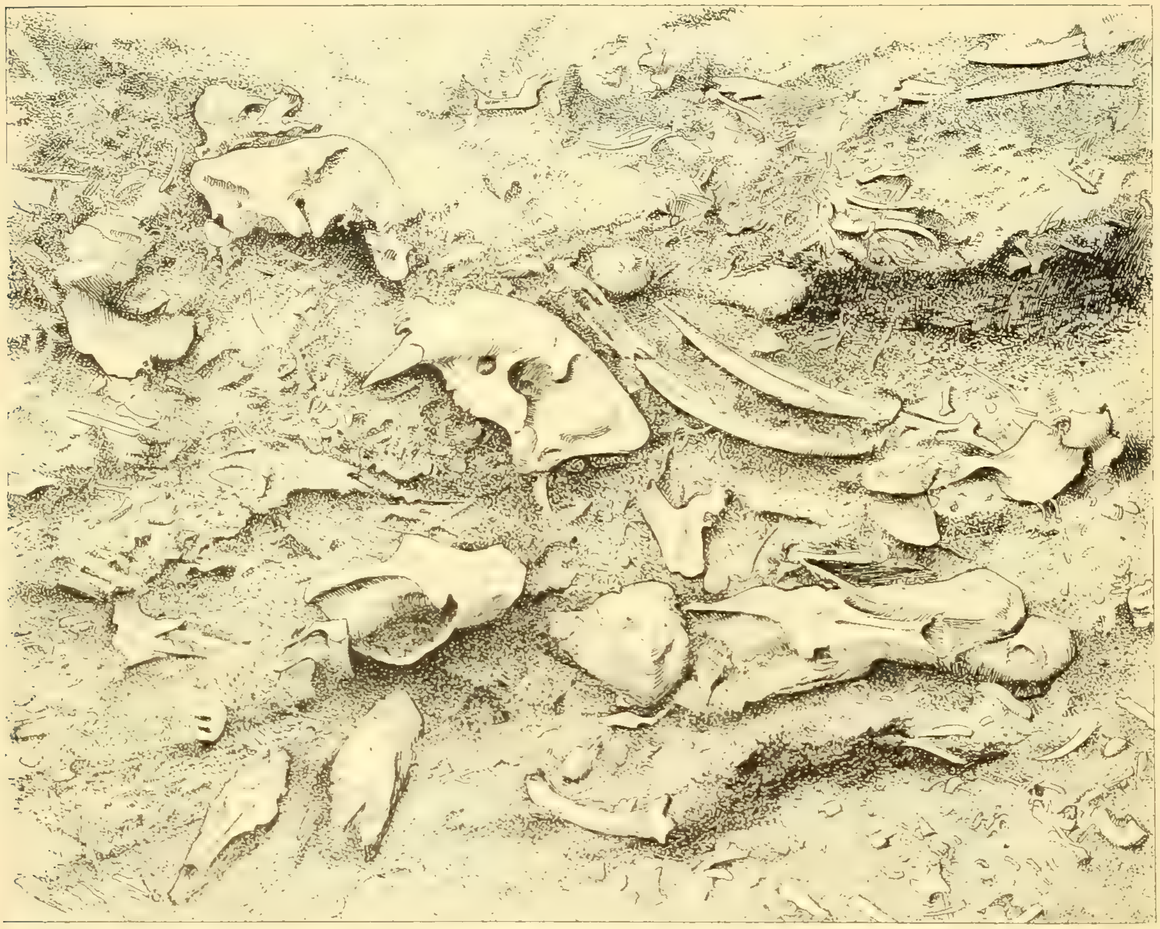


Fig. 1. A small area of asphalt in process of excavation, showing the skeletal remains before they had been completely uncovered. In this picture there may be seen the under side of the lower jaw of a horse, considerable parts of the skulls of four saber-tooth cats, four large wolf skulls, two coyote skulls, and many other skeletal parts only imperfectly exposed.

In addition to the natural accumulation of animal remains through the entangling of creatures of all kinds by accidental encountering of the tar, it is apparent from a study of the collections obtained that some extraordinary influence must have brought carnivorous animals of all kinds into contact with the asphalt with relatively greater frequency than other kinds of animals. In all the collections that have been examined the number of carnivorous mammals and birds represented is much greater than that of the other groups. A rough census of the University of California mammal collection from Rancho La Brea shows more representatives of the Carnivora than there are of all the other mammalian orders combined. A similar proportion of carnivorous birds has been noted by Miller[8] in the same collections. The number of carnivores represented is entirely out of proportion to the normal number of other animals present in the fauna, and is apparently to be explained by a peculiar process of selection, which may be seen in operation about tar pools at the present time. Whenever an animal of any kind is caught in the tar its struggles and cries naturally attract the attention of carnivorous mammals or birds in the immediate vicinity, and the trapped creature acts as a most efficient lure to bring these predaceous animals into the soft tar with it. It is not improbable that a single small bird or mammal struggling in the tar might be the means of entrapping several carnivores, which in turn would naturally serve to attract still others. The suggestion that struggling animals have served as a nearly continuous lure for Carnivora seems to be the only theory by which we can explain the remarkable entangled masses of carnivore bones which have been entombed in several places. In the first excavations carried on by the University of California a bed of bones was encountered in which the number of saber-tooth and wolf skulls together averaged twenty per cubic yard. More recently in the excavations carried on by Occidental College a nearly circular depression about three feet by six feet in diameter contained thirteen individuals of the saber-tooth, lion, and wolf in a depth of eight feet.

---

[8] Miller, L. H., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 306, 1909.

STATE OF PRESERVATION AND QUANTITY OF FOSSIL REMAINS

The skeletal remains obtained at Rancho La Brea vary greatly in the state of preservation at different horizons and at different places in the same bed, but in all cases the material seems to be the practically unaltered bone. In most localities the bones are fairly hard and are easily extracted from the matrix. In other places they are very soft and can be removed only with great difficulty. At still other points the enclosing asphalt is very hard and has the appearance of having been exposed to the sun and to weathering action for a long period. In these portions of the beds the bones can be separated satisfactorily only with the aid of chisel and mallet.

As the greater number of the animals entombed in the Rancho La Brea Beds have been entrapped in the tar, it is to be presumed that in a large percentage of cases the major portion of the skeleton has been preserved. Contrary to expectation, connected skeletons are not common. Several factors have evidently combined to scatter the skeletal parts. In most localities the tangled mass of bones shows that the tar at these points remained for a long period soft enough to engulf the bodies of animals, and during this time the struggles of each new victim tended to disturb the skeletons already in the pool. At times when the surface of the asphalt hardened by exposure, such bones as were uncovered may have been broken or perhaps completely destroyed by ungulates tramping over the spot. At all periods during the history of the deposit the viscosity of the asphalt apparently permitted considerable movements in the mass, and the individual bones were moved apart in the viscous layers. These movements would continue after the asphalt beds had been deeply buried by later accumulation, as the pressure of the mass above would at times cause a certain degree of flow in the tar beds.

The pressure of the rock mass does not seem in general to have distorted the bones greatly. Even the skulls of large animals commonly show comparatively little flattening or twisting. Where one bone has come to rest directly against another, the weaker or softer one is sometimes dented by the harder one; but where the pressure has been exerted through the asphalt above there has usually been change of position rather than change of form.

Judging by the results of excavations carried on up to the present time, the quantity of animal remains entombed in the beds at Rancho La Brea is large. The total area of asphalt in the region, including all of the small outcrops, probably amounts to the larger part of a square mile. A considerable part of this area presumably contains few bones, but fragments are present in a large

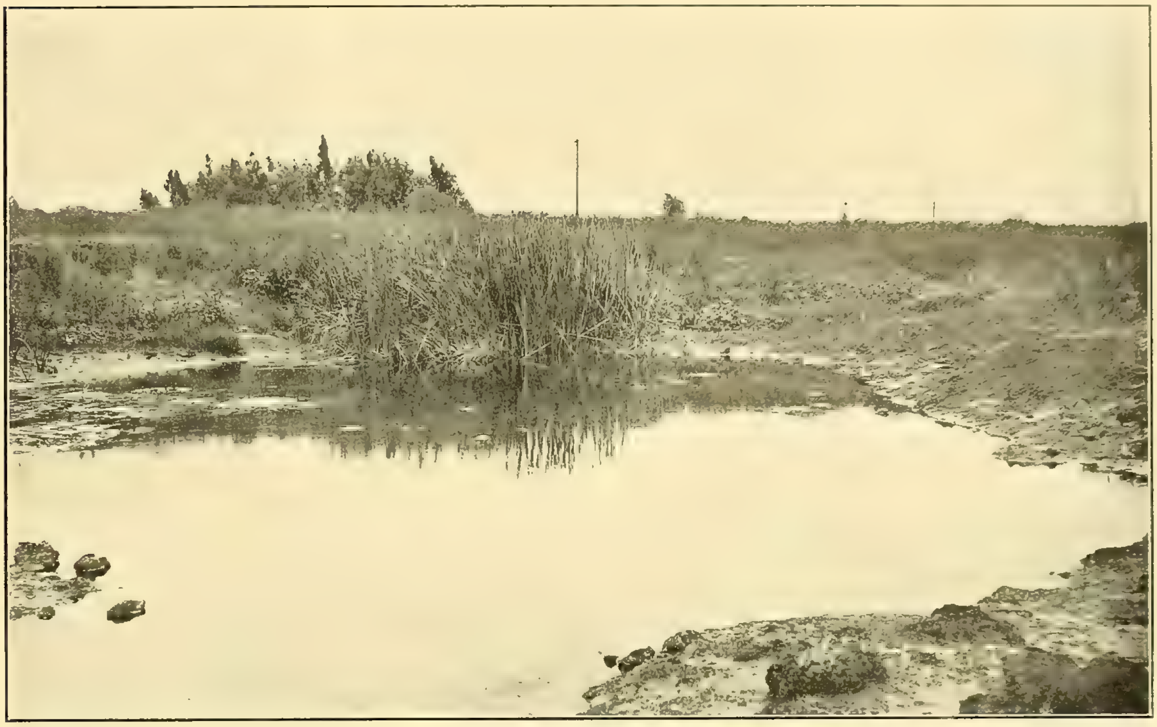


Fig. 1. A small pond with tar seeps near the border.

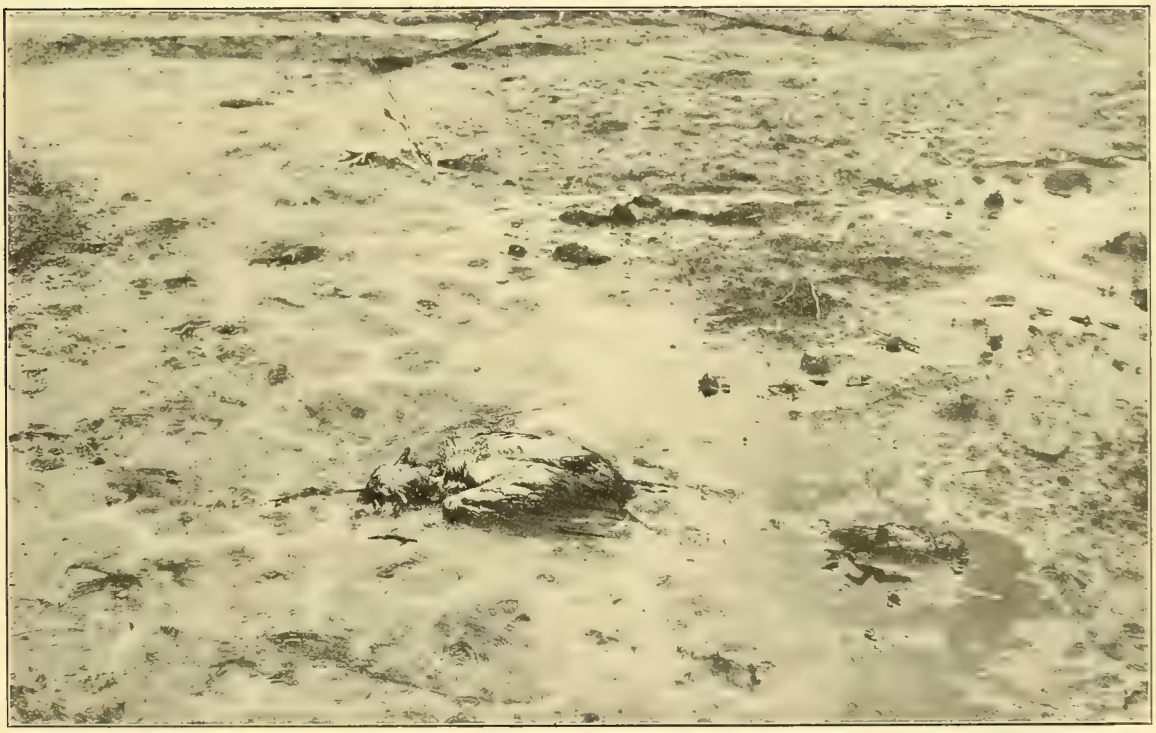


Fig. 2. A tar pool in which two birds had recently been caught. The smaller one, a meadow lark, seen in the lower right-hand corner of the picture, is nearly buried in the tar.

portion of the beds actually examined. In most of the prominent exposures at Rancho La Brea bones are generally present, though not always abundant. In these localities where any considerable amount of excavation work has been carried on they have usually been discovered in large quantities.

The locality at which the University of California excavations have been carried on has shown a most remarkable mass of skeletal material. During the first stage of the excavations careful count was made of the carnivore specimens obtained, and it appeared that there were thirty or more skulls of *Smilodon californicus,* with fifty or more heads of *Canis indianensis,* in a mass comprising less than four cubic yards. In addition to these skulls there were numerous remains of bison, horse, sloth, coyote, birds, and other forms.

At nearly all points where collecting has been done the skeletal material is somewhat irregularly distributed, and usually appears to be in rather small masses or pockets. The size and shape of these accumulations have presumably been dependent on the nature of the tar pools forming about the vents through which bituminous material has come to the surface.

While it is not safe to make any attempt at an estimate of the quantity of material represented in the whole area of the Rancho La Brea Beds, it is within the limits of probability to say that there are still some thousands of individuals of *Smilodon californicus* and *Canis indianensis* entombed in the deposits of this region. Of other forms the number is also probably very large, though somewhat less than in the case of the Carnivora.

Date of issue, November 9, 1911.

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 00749 3372